



CLINICAL STUDY

Effect of topical aerosol skin refrigerant (Spray and Stretch technique) on passive and active stretching[☆]

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 Myofascial trigger
 point

Summary

Objectives: The purpose of this study was to examine the effects of the use of a vapocoolant blend of pentafluoropropane and tetrafluoroethane (Gebauer's Spray and Stretch) on hip flexion stretching.

Methods: Thirty volunteers were randomly assigned to spray and stretch treatment and stretch only control groups. Each group was assessed pre- and posttest on passive and active hip flexion range of motion (ROM).

Results: Findings indicated greater posttest hip flexion gains for the spray and stretch group over the stretch only group for both active and passive ROM. Additionally, females achieved greater pre- and posttest differences on active ROM compared to males.

Conclusions: Study findings suggest that spray and stretch techniques can be an effective treatment in increasing hip flexion ROM.

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Introduction

Spray and stretch techniques have been widely used by clinicians to treat myofascial pain due to active trigger points, musculoskeletal dysfunction, and to increase range of motion (ROM) of various

joints (Travell, 1990; Simons et al., 1999; Kostopoulos and Rizopoulos, 2001). In 1981, Halkovich et al. (1981) conducted an experiment on hip flexion in which they randomly assigned 15 healthy subjects each to treatment and control conditions. The treatment group received a spray coolant between pre- and posttest assessments on ROM of hip flexion. The mean difference in pelvifemoral angle measurement for the experimental group was 1.21° compared to 0.21° for the control group, which was significant at the 0.02 level.

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Despite the success of the experiment, the widespread use of refrigerants for a wide variety of physical therapy applications, and its advocacy for treatment of myofascial trigger points (Simons et al., 1999; Simons and Mense, 2003), empirical investigations on the effectiveness of topical vapocoolants for increasing ROM have been practically non-existent. Searches of 27 medical and related health field databases, including Medline, Dissertation Abstracts, SciSearch, EMBASE, Allied and Contemporary Medicine, Manual, Alternative and Natural Therapy, and Global Health reveals three empirical investigations. Khalil and associates (1992) successfully used spray and stretch techniques in the alleviation of back pain and ROM in conjunction with several other techniques. Because the spray and stretch techniques were used in combination with other modalities, it was difficult to isolate their effects. Bengalia et al. (1999) used coolant and a thermoplastic splint along with exercises to help heal finger injuries in four professional volleyball players with positive results. The small sample size and the combination of therapeutic techniques did not allow for the independent effects of the coolant or the thermoplastic splint. Finally, Cheung and Robinson (2004) tested an upper body cooling garment on the performance of 10 bicycle sprinters. No significant differences were found under cooling and non-cooling conditions in heart rate, peak power, power output, or subjective sense of exertion. The latter three studies have serious design problems, including lack of controls, small sample size, and confounding of independent variables.

The present study seeks to replicate and extend the findings of Halkovich and associates (1981). The purpose of the study is to examine the effect of spray and stretch techniques on the ROM of hip flexion. This study is a replication because the dependent and independent variables are the same. It is an extension of the findings of Halkovich et al. for the following reasons: first, fluorimethane has been replaced by a combination of pentafluoropropane and tetrafluoroethane because of the deleterious effects of fluorimethane on the ozone layer (Simons et al., 1988). Second, the technology for stabilizing the body for ROM measurements has been improved. Third, measuring devices have become much more sophisticated since 1981. Fourth, Halkovich et al. reported only on passive ROM, while this study tested both passive and active ROM of hip flexion. In the Halkovich study, a force table was improvised by attaching a skateboard arm that had ball bearings. This study was done before microcomputers, much less handheld computing devices. Assessment

devices were cumbersome, perhaps leading to increased standard errors of measurement.

The hypotheses of this study are:

1. spray and stretch procedures will increase passive ROM significantly more than stretching without spraying and
2. spray and stretch procedures will increase active ROM significantly more than stretching without spraying.

Method

Sample

The sample has 30 healthy individuals, 15 males and 15 females. The mean age was 26.10 years (SD = 5.82), with a range of 17–41 years. Study participants were randomly assigned to experimental and control conditions using a random number generator. No significant differences were found on age or gender distributions between the experimental and control groups.

Instrumentation

Active and passive ROM was measured using a Dualer IQ Inclinometer (J-Tech Medical, Salt Lake City, UT). Lantz et al. (1999) conducted a validity study on electronic goniometry using a sample of 63 healthy male and female college students on cervical movement using two instruments. Test-retest data after 1 week were obtained for a sample of 33 students. Assessments were conducted for rotation, lateral bending, and flexion-extension. Each movement was repeated 6 times with two examiners. Intraclass correlations (ICCs) were computed for intra- and interrater differences for the three movements for both active and passive motion.

The ICCs for active ROM ranged between 0.65 and 0.97, with a median of 0.85; for passive ROM, the range was between 0.59 and 0.90, with a median of 0.74. No discernible differences could be found between intra- and interrater differences. On pretest/posttest differences, posttest assessments were regressed on pretest scores with the instrument as a factor. Between-instrument differences were close to zero. R^2 coefficients ranged between 0.43 and 0.81 with a median of 0.74 for active ROM. For passive ROM, they ranged from 0.48 to 0.76 with a median of 0.64. Of 18 measures between pre- and posttest (three measures (rotation, lateral bending), times three (two raters

individually+combined) times two types of motion (active and passive)), three were significant. The authors concluded that the electronic devices assessing goniometry were reliable and valid. However, reliability was higher for active ROM than passive ROM. This suggested that further refinements needed to be done for passive ROM reliability. Therefore, the device was pilot tested by this research team with two judges and 10 healthy participants for passive ROM for flexion of right and left hips. Two-way mixed effect model ICCs were ran for right and left sides individually and for both sides. The ICCs for each side and for both sides combined were 0.99. SEMs for pre- and posttest active and passive ROM were quite small, ranging from 0.72 to 0.77. Kolmogorov–Smirnov tests were computed on the distributions for pre- and posttest active and passive ROM. None violated the assumption of approximation to a normal distribution.

Muscle tension was assessed using the Commander Powertrack II dynamometer (J-Tech Medical, Salt Lake City, UT). The Commander Powertrack II is a handheld device designed to record peak force and strength deficits. It is designed to store 40 bilateral tests with four repetitions for each side. Bohannon (1999) reviewed 12 studies that reported on the reliability and validity of handheld dynamometry. He noted that handheld devices had several advantages: portability, expense, simplicity and objectivity. The main problem with dynamometry is the skill of the person using the device. Interrater reliability coefficients from the 12 studies varied widely from 0.19 to 0.99, with a large majority above 0.70. Coefficients were higher for measures of upper extremities for lower extremities. In the case of this study, the dynamometer is being used to assess muscle tension at the point at which the patient feels a pull.

Procedures

All study participants were given a form that explained the purpose of the study, the nature and time commitment of their participation, potential risks and benefits, and their rights to confidentiality, refusal without retribution, and access to the findings of the study. Potential risks were pointed out as follows: overapplication could lead to freezing, skin irritation, and/or alteration of the skin pigmentation. Spraying near the face or on open wounds could lead to irritation of the eyes, mucous membranes, or open sores. Because the product was not to be used with persons with diabetes, poor circulation, or insensitive skin, all

patients were asked if they had any of those medical problems. Any participant having open sores in the spray area or had any of the above medical problems was excluded from the study. Each participant was asked to read over the document in the presence of a staff member from Hands-On Physical Therapy. Prospective participants were asked if they had any questions about their participation. They were told that if they agreed to participate they were to print their name, enter the date, and signed a consent form. The staff member signed the form as a witness. The signed form was copied with Hands-On Physical Therapy retaining the original and the participant receiving the photocopy. In the case of the 17-year-old participant, two forms were issued, one for the participant and one for the parent. Both were signed and witnessed.

Subjects were placed on a plinth assuming a left side-lying position with the right lower extremity securely positioned and supported by a support board on wheels that can freely move on a smooth surface, minimizing ground friction. The purpose of the board is to support the weight of the lower extremity in a gravity-eliminated and neutral position for hip abduction/adduction. The pelvis was stabilized at the area of the anterior superior iliac spines with a special pelvic stabilization belt. Additional stabilization of the sacrum area and left hip was achieved by means of fitted pads and belts. After each subject was positioned and stabilized, passive ROM of right hip flexion was measured with the knee extended. This measurement and placement of inclinometer sensors was performed based on the training manual and online course provided by J-Tech Medical. For hip flexion ROM, the inclinometer measured pelvifemoral angle, which is defined as the angle constructed by two lines: one between the tip of Anterior Superior Iliac Spine and tip of ischial tuberosity and the other depicting the long axis of the lower extremity (Figure 1).

At the point where each subject acknowledged a "pulling," a threshold resistance force produced by the subject's hip extensor musculature was obtained for passive hip flexion. This threshold resistance force is defined as the resistance force produced when a pulling sensation is evoked in the right popliteal fossa with the knee in 180° of extension, when the subject's right lower extremity is moved by the therapist towards hip flexion at about 5° a second. At that point the therapist stopped the movement and used a Commander Powertrack II dynamometer to measure the threshold resistance force produced by the subject's hip extensor musculature. The dynamometer was securely fastened on a fixed stand to avoid any



Figure 1 Position of subject for the passive range of motion testing.



Figure 2 Spraying the hip.

measurement error due to movement and measurements were taken with the dynamometer placed at the area right above the Achilles tendon.

The identification of a threshold resistance force ensures that the hip was passively flexed with the same amount of force following treatment procedures. At the point the subject acknowledged the pulling previously described, measurements of the degree of hip flexion were recorded by the inclinometer.

When all measurements were completed, the testing therapist left the room and a treatment therapist entered. Experimental-group subjects were given application of blend of pentafluoropropane and tetrafluoroethane (Gebauer's Spray and Stretch[®]) vapocoolant for over approximately a 45-s period, applied by the treating therapist

according to the specifications supplied by the producer. The area of the skin overlying the entire length between the attachments of the semimembranosus, semitendinosus, and biceps femoris muscles were sprayed using vapocoolant. Six spray applications, each lasting about 5 s on and 3 s off, were applied over the area. Application of the vapocoolant were administered with the hip and knee maintained in the same position that measurements were recorded. The rate of sweep was maintained at about 12 cm a second and each sweep took 5 s to complete (Figure 2).

Control subjects received no application of vapocoolant, instead they were maintained in the threshold resistance force position for a similar 45-s period. Following the 45-s period, the treating therapist left the room and the testing therapist

who has no knowledge of the patient assignment to experimental or control group entered the room and rechecked the threshold resistance force reading as recorded by the dynamometer. If this second force reading varied from the pretest threshold resistance force reading, then the right lower extremity was repositioned accordingly until the pretest threshold resistance force reading was re-established. At this point the posttest hip flexion ROM was recorded by the inclinometer.

Once passive ROM was tested, subjects were placed on a plinth assuming a right side-lying position with the left lower extremity securely positioned and supported by the support board on wheels that can freely move on a smooth surface, minimizing ground friction. From this position the left hip active ROM was recorded. The pelvis, sacrum, and right hip were stabilized as with the previous testing.

The Dualer IQ Inclinometer was used to assess active ROM of the left hip joint in each subject. Each subject was asked by the testing therapist to flex their hip actively to the maximum of their ability. At that point the pretest recording of the hip flexion ROM was obtained from the inclinometer. At this time the testing therapist left the room and the treating therapist entered the room.

Experimental-group subjects were given application of vapocoolant following the same guidelines as previously described. Control subjects received no application of vapocoolant, but they were maintained in the threshold resistance force position for a similar 45-s period. Following the 45-s period, all subjects were asked by the testing therapist to return to 0° of hip flexion and immediately thereafter were asked to flex their hip actively to the maximum of their ability. At this point the posttest hip flexion ROM was recorded by the inclinometer.

Results

Hypothesis 1 was tested using a two-way (group-gender) analysis of covariance (ANCOVA) in which threshold resistance and pretest ROM were entered as covariates in order to control their influences on posttest ROM. The descriptive statistics are presented in Table 1 and the summary of the ANCOVA is presented in Table 2. Between pre- and posttest assessments, the control group improved 0.47° from 73.93° (standard deviation [SD] = 4.15) to 74.40° (SD = 3.76); the spray and stretch experimental group improved 1.80° from 74.40° (SD = 4.03) to 76.20° (SD = 4.04). Group differences were significant ($F_{[1,29]} = 6.30$, $p = 0.02$,

Table 1 Descriptive statistics for passive range of motion by group and gender.^a

Group/gender	N	Pretest		Posttest	
		M ^a	SD	M ^a	SD
Control	15	73.93	4.15	74.40	3.76
Male	8	75.25	4.53	75.63	4.07
Female	7	72.43	3.36	73.00	3.06
Experimental	15	74.40	4.03	76.20	4.04
Male	7	72.86	4.34	75.29	3.73
Female	8	75.75	3.45	77.00	4.38
Total	30	74.17	4.03	75.30	3.94
Male	15	74.13	4.45	75.47	3.78
Female	15	74.20	3.71	75.13	4.22

M, mean; SD, standard deviation.

^aMeans are in degrees.

$\eta^2 = 0.21$), accounting for 21% of the total variance. No significant gender differences were found, nor was there any significant group by gender interaction. Hypothesis 1 was supported by the findings.

Hypothesis 2 was tested using a similar statistical design as Hypothesis 1; however, threshold resistance was removed as a covariate. The descriptive statistics are in Table 3 and the summary of the ANCOVA is in Table 4. For active ROM, the control group increased 0.40° from 73.60° (SD = 3.92) to 74.00° (SD = 3.70); the spray and stretch experimental group improved 1.93° from 74.07° (SD = 4.65) to 76.00° (SD = 4.22). Group differences were significant ($F_{[1,29]} = 8.05$, $p < 0.01$, $\eta^2 = 0.24$), accounting for 24% of the total variance. Hypothesis 2 was supported by the findings. Significant gender differences ($F_{[1,29]} = 6.21$, $p = 0.02$, $\eta^2 = 0.20$) were found in favor of the females who improved 1.80° compared to 0.57° for the males. Gender accounted for 20% of the total variance. No significant gender × group interactions were found.

Discussion

The findings of this study essentially replicated those of Halkovich and associates (Halkovich, Personius et al., 1981), with somewhat stronger results. Halkovich et al. assessed only passive ROM, while this research addressed both passive and active ROM, finding similar between-group differences for both dependent measures. Although

Table 2 Summary of analysis of variance for passive range of motion by group and gender.

Source	SS	df	MS	F	p	Partial η^2
Corrected model	392.10	5	78.42	32.34	0.00	0.87
Threshold resistance (lbs.)	2.37	1	2.37	0.98	0.33	0.04
Pretest ROM	302.52	1	302.52	124.75	0.00	0.84
Group	15.28	1	15.28	6.30	0.02	0.21
Gender	1.67	1	1.67	0.69	0.41	0.03
Group \times gender	1.14	1	1.14	0.47	0.50	0.02
Error	58.20	24	2.43			
Total	450.30	29				

SS, type III sum of squares; df, degrees of freedom; MS, mean square; F, Fischer's F statistic; Sig., significance level; ROM, range of motion.

Table 3 Descriptive statistics for active range of motion by group and gender.^a

Group/gender	N	Pretest		Posttest	
		M ^a	SD	M ^a	SD
Control	15	73.60	3.92	74.00	3.70
Male	8	74.63	4.66	74.38	4.66
Female	7	72.43	2.76	73.57	2.51
Experimental	15	74.07	4.65	76.00	4.42
Male	7	71.71	5.06	73.14	4.06
Female	8	76.13	3.31	78.50	3.12
Total	30	73.83	4.24	75.00	4.14
Male	15	73.27	4.91	73.80	4.28
Female	15	74.40	3.52	76.20	3.75

M, mean; SD, standard deviation.

^aMeans are in degrees.

Halkovich et al. reported an increase of 1.21° in their experimental sample, the vapocoolant sample increased passive ROM 1.80° and active ROM 1.93°, while the control group increased 0.47° and 0.40°, respectively. The control group differences are approximately twice the magnitude of those reported by Halkovich et al.

The findings of this study reinforce those of Halkovich et al. (1981) that vapocoolant sprays help patients increase their hip flexion ROM. Confidence in these findings are enhanced in several ways: (1) as noted above, descriptive statistics of this study are similar to those reported 25 years ago; (2) in this study, similar findings were reported for both passive and active ROM; (3) technologies were used that increased the precision of measurements over those conducted 25 years ago; and (4) the research design included

conducting reliability checks for assessing hip flexion ROM, indicating very high reliability.

An additional finding of this study indicated that on active ROM, females seemed to show greater gains in hip flexion than males from pre- to posttest. Because there was no interaction between gender and group membership, this artifact seems to be not related to the use of spray and stretch techniques, but rather, to anatomical differences between males and females.

The factors involved in the outcome of this study can include both mechanical and neurophysiological. Mechanical factors involve the effect of static passive stretch in muscle stiffness and its subsequent effect in ROM. Nordez et al. (2006) assessed the effects of static stretching on hamstring passive stiffness calculated using different data reduction methods. Subjects performed a maximal ROM test, five cyclic stretching repetitions and a static stretching intervention that involved five 30-s static stretches. After stretching, while knee maximal joint ROM increased, stiffness was shown to decrease. Such mechanical effects of passive stretch have been very well established. Neurophysiological factors involve the effects of the decrease of skin temperature in the intrafusal fibers which further control muscle tension. Tanaka et al. (2006) investigated the nature of muscle efferent and afferent fiber activation during whole body cooling in 20 adult male rats. The researchers reported evidence for a thermoregulatory reflex which activates fusimotor fibers in response to skin cooling. The activation of efferent activity was exclusively of fusimotor fibers and with evidence that it was not accompanied by α -motorneuron activity. The researchers identified also evidence of sensitization of muscle spindle afferent activity. The activation pattern of spindle afferent sensitization during cooling was with steady increases in

Table 4 Summary of analysis of variance for active range of motion by group and gender.

Source	SS	df	MS	F	p	Partial η^2
Corrected model	442.76	4	110.69	51.98	0.00	0.89
Pretest ROM	303.21	1	303.21	142.39	0.00	0.85
Group	17.15	1	17.15	8.05	0.01	0.24
Gender	13.22	1	13.22	6.21	0.02	0.20
Group \times gender	0.56	1	0.56	0.26	0.61	0.01
Error	53.24	25	2.13			
Total	496.00	29				

SS, type III sum of squares; df, degrees of freedom; MS, mean square; F, Fischer's F statistic; Sig., significance level; ROM, range of motion.

tonic firing with little or no adaptation to a maintained stretch. The researchers concluded that this increased afferent and efferent activation has as a purpose to increase muscle tone by enhancing tonic activity and lead to shivering.

Obviously, if the results of Tanaka et al.'s (2006) study were applicable to the application of a vapocoolant, we would rather observe an increase in muscle tone with an increase in muscle tension and with further decrease in ROM during stretching. However, the researchers clearly point out that this mechanism applies only to whole body cooling, which results in the activation of a cold-defense response. Local cooling of the paw pad of anaesthetized cats has been used to activate fusimotor fibers supplying muscles of the same limb (Lupandin, 1983; Lupandin and Kuz'mina, 1985). Cooling a single body part versus the whole body will not provide much drive for thermoregulation (Tanaka et al., 2006). The effects of single body part skin cooling can be interpreted as segmental or with the involvement of local spinal reflexes. Lupandin (1983) and Lupandin and Kuz'mina (1985) reported activation of flexor and simultaneous inhibition of extensor gamma-motoneurons with secondary activation of flexor alpha-motoneurons. Lupandin's outcome may provide a reasonable explanation regarding the decreased tension we observed in the hip extensor musculature with the application of the vapocoolant but also an increase in ROM during active hip flexion.

Vapocoolants have a long history of experimental and clinical use. Hong and Shellock (1991) found that Eucalyptamint application increased cutaneous blood flow and skin temperatures lasting up to 45 min after the application. Muscle temperatures were also increased significantly 30 min after the application on 10 normal human subjects. They concluded that the application of Eucalyptamint may be beneficial for pain relief and useful to athletes is a passive form of warm-up. Other

agents, such as capsaicin (Abbott et al., 1984) and menthol (Futami, 1984; Ragan et al., 2004) have been found to have analgesic effects in animals. Abbott et al. found that capsaicin was instrumental in reducing non-damaging heat pain, but not pain resulting from tissue damage in rats. Ragan et al. reported that the application of menthol analgesic balm had short-term effects on pain responses in decerebrated cats and Futami reported that the application of menthol resulted in vasodilation and pain relief in rabbits. Eucalyptamint, menthol, and capsaicin all seem to increase muscle temperature and blood flow, subsequently providing pain relief. Spray and Stretch operates differently. It seems to have a neurophysiological effect that involves a sudden decrease in skin temperature affecting the intrafusal fibers that further control muscle tension.

Simons and Mense (2003) advocate the use of vapocoolant spraying for the management of myofascial trigger points. These researchers support that the sudden cold and the tactile stimulation provided by the vapocoolant spray, inhibit the pain and the reflex motor, and autonomic responses in the central nervous system. When the pain stimuli subside or suppress, an effective relaxation takes place that allows the gently stretching and lengthening of the muscle. During our study each subject reported when they felt a "pulling" in the popliteal area while moved to hip flexion. This "pulling" essentially represents a threshold resistance force or muscle tension produced by the subject's hip extensor musculature. Spraying the area with a vapocoolant may have produced a similar effect as described by Lupandin (1983), Lupandin and Kuz'mina (1985) (Figure 3).

In conclusion, the findings of the study support the use of aerosol skin refrigerants as a therapeutic technique in helping patients increase hip flexion. Vapocoolants may be beneficial for patients recovering from hip injuries or hip placement surgery.

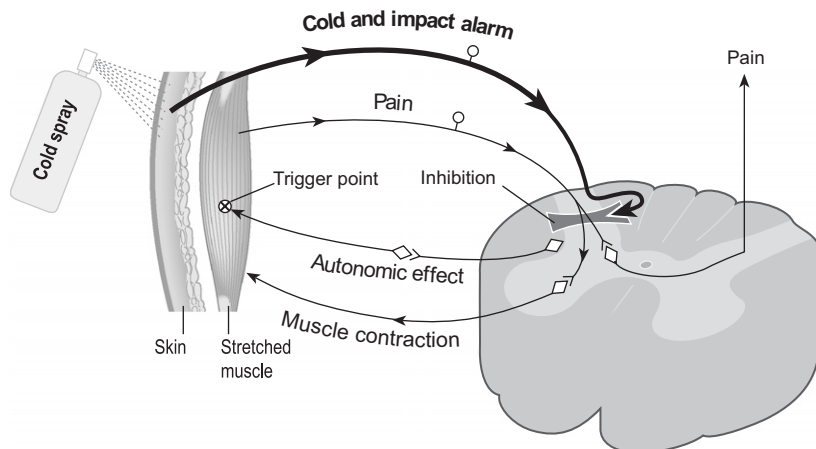


Figure 3 Schematic representation of neural pathways.

They help to reduce pain and increase hip flexion, especially among women. The findings of the study support the use of vapocoolants in therapeutic treatments of the hip. They may be viable in the treatment of other joints as well, including ankles, knees, shoulders, and neck. This study has opened new ground in the use of vapocoolants in physical therapy.

This study was conducted to shed new light on a commonly used technique among clinicians. It helps to change the perception of the use of vapocoolants for hip flexion from an article of faith to an empirically verified therapeutic technique. More research needs to be conducted on the use of vapocoolants in increasing patients' ROM.

Conflicts of interest

The authors have no commercial, proprietary, or financial interest (as consultants, reviewers, or evaluators) in the Gebauer Company and declare there are no additional conflicts of interest.

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References

Abbott, F.V., Grimes, R.W., et al., 1984. Single nerve capsaicin: effects on pain and morphine analgesia in the formal and in foot-flick tests. *Brain Research* 295 (1), 77–84.

- Bengalia, P.G., Sartorio, F., et al., 1999. A new thermoplastic splint for proximal interphalangeal joint flexion contractures. *Journal of Sports Medicine and Physical Fitness* 39 (3), 249–252.
- Bohannon, R.W., 1999. Intertester reliability of hand-held dynamometry: a concise summary of published research. *Perceptual and Motor Skills* 88, 899–902.
- Cheung, S., Robinson, A., 2004. The influence of upper-body pre-cooling on repeated sprint performance in moderate ambient temperatures. *Journal of Sports Sciences* 22 (7), 605–612.
- Futami, T., 1984. Actions and mechanisms of counterirritants on muscular circulation. *Folia Pharmacologica Japonica* 83 (3), 219–226.
- Halkovich, L.R., Personius, W.J., et al., 1981. Effect of fluorimethane[®] spray on passive hip flexion. *Physical Therapy* 61 (2), 185–189.
- Hong, C.Z., Shellock, F.G., 1991. Effects of a topically applied counterirritant (eucalyptamint) on cutaneous blood flow and on skin and muscle temperatures: a placebo-controlled study. *American Journal of Physical Medicine and Rehabilitation* 70 (1), 29–33.
- Khalil, T.M., Asfour, S.S., et al., 1992. Stretching in the rehabilitation of low back pain patients. *Spine* 17 (3), 311–317.
- Kostopoulos, D., Rizopoulos, K., 2001. *The Manual of Trigger Point and Myofascial Therapy*. Slack, Inc., Thorofare, NJ.
- Lantz, C.A., Chen, J., et al., 1999. Clinical validity and stability of active and passive cervical range of motion with regard to total unilateral uniplanar motion. *Spine* 24 (11), 1082–1089.
- Lupandin, L., 1983. Regulation of the function of gamma- and alpha-motor neurons of antagonist muscles during cold tremor in the cat. *Neurofiziologija* 15 (3), 242–248.
- Lupandin, L., Kuz'mina, G.L., 1985. Interaction of thermoreceptive and vestibular signalling in regulating the activity of flexor and extensor motor nuclei during cold tremor. *Fiziol Zh SSSR Im I M Sechenova* 11 (71), 1433–1438.
- Nordez, A., Cornu, C., et al., 2006. Acute effects of static stretching on passive stiffness of the hamstring muscles calculated using different mathematical models. *Clinical Biomechanics* 21 (7), 755–760.
- Ragan, B.G., Nelson, A.J., et al., 2004. Effects of the menthol-based analgesic balm on presser responses evoked from muscle afferents in cats. *American Journal of Veterinary Research* 65 (9), 1204–1210.
- Simons, D.G., Mense, S., 2003. Diagnosis and therapy of myofascial trigger points. *Shmerz* 17 (6), 419–424.

- Simons, D.G., Travell, J.G., et al., 1988. Protecting the ozone layer. *Archives of Physical Medicine and Rehabilitation* 69 (11), 992–993.
- Simons, D.G., Travell, J.G., et al., 1999. *Myofascial Pain and Dysfunction: The Trigger Point Manual*. Williams and Wilkins, Baltimore, MD.
- Tanaka, M., Owens, N.C., et al., 2006. Reflex activation of rat fusimotor neurons by body surface cooling, and its dependence on the medullary raphe. *Journal of Physiology (London)* 572 (Part 2), 569–583.
- Travell, J.G., 1990. Chronic myofascial pain syndromes: mysteries of the history. *Advances in Pain Research and Therapy* 17, 129–137.

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